

WHAT IS CLAIMED IS:

1. An optical probe system comprising:
 - an optical probe to be inserted into a body cavity;
 - a light source that generates light which is irradiated to an object;
 - a high-magnification observation unit incorporated in the distal section of the optical probe;
 - an image digitization unit that digitizes a luminance signal produced by the high-magnification observation unit;
 - an image parameter sampling unit that samples an image parameter from an image;
 - an optimization parameter calculation unit that calculates an optimization parameter on the basis of the image parameter;
 - an image optimization unit that optimizes an image according to the optimization parameter;
 - an image display device on which an optimized image is displayed; and
 - a digital image preservation unit in which a digital image is preserved.
2. An optical probe system according to Claim 1, wherein the image parameter is a luminance parameter.

3. An optical scanning probe system according to Claim 2, wherein the luminance parameter indicates maximum brightness or minimum brightness.

4. An optical scanning probe system according to Claim 3, wherein before the image parameter sampling unit samples the image parameter, a noise is canceled.

5. An optical scanning probe system according to Claim 2, wherein the luminance parameter indicates an average of the luminance values of all pixels.

6. An optical scanning probe system according to Claim 2, wherein the luminance parameter is provided as a histogram plotted based on the luminance values of all pixels.

7. An optical scanning probe system according to Claim 2, wherein the luminance parameter sampling unit samples a luminance signal using an analog electronic circuit.

8. An optical scanning probe system according to Claim 2, wherein the luminance parameter sampling unit is realized with an algorithm that is programmed in a computer and that is applied to an digitized image.

9. An optical scanning probe system according to Claim 2, wherein the image optimization unit is a luminance conversion unit that converts a luminance value.

10. An optical scanning probe system according to Claim 9, wherein the luminance conversion unit is realized with an algorithm that is programmed in a computer and that is applied to a digitized image.

11. An optical scanning probe system according to Claim 9, wherein the luminance conversion unit converts a luminance signal using an analog electronic circuit.

12. An optical scanning probe system according to Claim 2, wherein before the image digitization unit digitizes a luminance signal, a dynamic range compression unit compresses the dynamic range.

13. An optical scanning probe system according to Claim 12, wherein the compression of the dynamic range is achieved through logarithmic conversion.

14. An optical scanning probe system according to Claim 12, wherein the compression of the dynamic range is

achieved through gamma conversion.

15. An optical scanning probe system according to Claim 12, wherein inverse transformation is performed on an image digitized by the image digitization unit, and the image is thus optimized.

16. An optical scanning probe system according to Claim 12, wherein at least one of a luminance parameter and an optimization parameter is preserved together with a digitized image in the digital image preservation unit.

17. An optical scanning probe system according to Claim 16, wherein the digitized image to be preserved is an image that has not yet been optimized.

18. An optical scanning probe system according to Claim 16, wherein the digitized image to be preserved is an image that has been optimized.

19. An optical scanning probe system according to Claim 2, wherein the optimization parameter calculation unit calculates an optimization parameter using at least one of the past image parameter and a luminance parameter.

20. An optical scanning probe system according to Claim 1, wherein the image optimization unit and digital image preservation unit process time-sequentially consecutive images.

21. An optical scanning probe system according to Claim 20, wherein the image optimization unit selects and displays an image that depicts an edge at a luminance level equal to or higher than a predetermined level.

22. An optical scanning probe system according to Claim 21, wherein the image optimization unit deals with a luminance parameter relative to a threshold value so as to detect an in-focus image.

23. An optical scanning probe system according to Claim 21, wherein the image optimization unit deals with a value, which is calculated by integrating the luminance values of a high-frequency component of an image, relative to a threshold value so as to detect an image depicting a contour.

24. An optical scanning probe system according to Claim 23, wherein a method of detecting the high-frequency component is a differential.

25. An optical scanning probe system according to Claim 23, wherein only an image that depicts an edge at a luminance level equal to or higher than a predetermined level is preserved in the digital image preservation unit.

26. An optical scanning probe system according to Claim 23, wherein information concerning the presence or absence of an image that depicts an edge at a luminance level equal to or higher than a predetermined level is preserved in the digital image preservation unit.

27. An optical scanning probe system according to Claim 20, wherein a plurality of images is displayed on the same screen of the image display unit.

28. An optical scanning probe system according to Claim 27, wherein the plurality of images to be displayed is determined with a time instant at which an image is produced and an image parameter.

29. An optical scanning probe system according to Claim 20, wherein the image parameter sampling unit samples a characteristic quantity from an image, and the image optimization unit concatenates a plurality of images, which

is acquired temporally continuously, on the basis of the characteristic quantities sampled from the images so as to produce an image.

30. An optical scanning probe system according to Claim 20, further comprising a depth change unit that shifts an imaged range in a depth direction, and an image acquisition unit that acquires time-sequential images while the depth change unit changes a depth of observation.

31. An optical scanning probe system according to Claim 30, wherein the digital image preservation unit simultaneously records an image, at least one of an image parameter and an optimization parameter, and depth information concerning a depth of imaging.

32. An optical scanning probe system according to Claim 30, wherein time-sequential images are acquired by varying the depth of observation in order to produce a two-dimensional tomographic image or a three-dimensional image.

33. An optical scanning probe system according to Claim 1, wherein the high-magnification observation unit comprises:

a condenser that converges or emits light emanating

from a light source;

an optical scanning unit that scans a focal point on an object, at which the light is converged by the condenser, in a direction orthogonal to the optical-axis directions of the condenser; and

a photo-detection device that detects light returning from the object.

34. An optical scanning probe system according to Claim 33, further comprising an optical fiber over which the light emanating from the light source is introduced into the condenser, and a separator that separates the light returning from the object from the light path emanating from the light source, wherein:

when the photo-detection device detects the light separated by the separator, the end of the optical fiber and the object have a confocal or near confocal relationship to each other and share the same focal point on the condenser.

35. An optical scanning probe system according to Claim 34, wherein the photo-detection device is formed with a photo detector.

36. An optical scanning probe system according to Claim 34, wherein the photo-detection device is formed with

a photomultiplier tube.

37. An optical scanning probe system according to Claim 33, wherein the light source is formed with a laser.

38. An optical scanning probe system according to Claim 37, wherein the laser is a semiconductor laser.

39. An optical scanning probe system according to Claim 33, wherein the condenser includes at least one lens that concentrates light on an object.

40. An optical scanning probe system according to Claim 1, wherein the light source is a low-coherent light source, further comprising:

a splitter that splits light emanating from the light source into observation light that is routed to the condenser, and reference light; and

a coupler that couples light returning from the object and the reference light so as to complete interference, wherein:

the photo detector detects the light coming from the coupler; and

the signal processing unit samples an interference signal from a signal produced by the photo detector.

41. An optical scanning probe system according to Claim 40, wherein the optical path length for the observation light and the optical path length for the reference light agree with each other at a point near a point on which light is converged by the condenser.

42. An optical scanning probe system according to Claim 1, further comprising:

a display/preservation selection device that is used to select or designate display/preservation parameters, which determine a method of displaying and preserving an image, on the image display device; and

a control device that controls any one of the light source, image display device, and digital image preservation unit on the basis of the display/preservation parameters, and executes display and preservation.

43. An optical scanning probe system according to Claim 42, wherein the display/preservation parameters include at least one of:

a parameter concerning a display/preservation mode in which at least a specific image is displayed and/or preserved;

a parameter concerning a reference for selection based

on which an image to be displayed on the image display device, that is, an object of display and/or preservation is specified;

a parameter concerning simultaneously preserved data, that is, data other than an image that should be preserved together with an image displayed on the image display device;

a parameter concerning timing of preservation, that is, at what timing an image displayed on the image display device should be preserved; and

a parameter concerning blur correction, that is, whether a blur in an image displayed on the image display device should be corrected.

44. An optical scanning probe system according to Claim 43, wherein the display/preservation selection device is used to select or designate the display/preservation mode from among:

a specific-image display/preservation mode in which a specific image alone is displayed and preserved;

a specific-image display/all-images preservation mode in which a specific image alone is displayed and all images are preserved;

an all-images display/specific-image preservation mode in which all images are displayed and a specific image alone

is preserved; and

an all-images display/preservation mode in which all images are displayed and preserved.

45. An optical scanning probe system according to Claim 43, wherein the display/preservation selection device is used to select or designate the reference for selection from among:

a luminance value represented by a luminance signal sampled by the high-magnification observation unit;

an area that is defined within an image range produced by the high-magnification observation unit;

a frame image that specifies a certain number of frame images from among time-sequentially consecutive frame images; and

a time during which a specific frame image out of time-sequentially consecutive frame images is displayed or preserved.

46. An optical scanning probe system according to Claim 45, wherein the control device controls the image display device and digital image preservation unit so that:

an image whose luminance value is equal to or larger than a predetermined luminance value will be displayed and/or preserved; and

an image whose luminance value falls below the predetermined luminance value is not displayed and/or preserved.

47. An optical scanning probe system according to Claim 46, wherein the control device controls the image display device and digital image preservation unit so that:

when the reference for selection is set to the luminance value, an image whose luminance value is equal to or larger than the predetermined luminance value and which depicts an object in a size equal to or larger than a predetermined size will be displayed and/or preserved; and

an image whose luminance value falls below the predetermined luminance value and which depicts an object in a size falling below the predetermined size will not be displayed and/or preserved.

48. An optical scanning probe system according to Claim 46, wherein when the reference for selection is set to the luminance value, the display/preservation selection device can be used to set the predetermined luminance value to any value.

49. An optical scanning probe system according to Claim 46, wherein when the reference for selection is set to

the luminance value, the display/preservation selection device can be used to set the predetermined luminance value and predetermined object size to any values.

50. An optical scanning probe system according to Claim 45, wherein the control device controls the image display device and digital image preservation unit so that when the reference for selection is set to the area, a predetermined area alone will be displayed and/or preserved but the other area will not be displayed and/or preserved.

51. An optical scanning probe system according to Claim 50, wherein when the reference for selection is set to the area, the display/preservation selection device can be used to set the predetermined area to any area.

52. An optical scanning probe system according to Claim 45, wherein when the reference for selection is set to the frame image, the control device controls the image display device and digital image preservation unit so that a predetermined frame image alone will be displayed and/or preserved but the other frame images will not be displayed and/or preserved.

53. An optical scanning probe system according to

Claim 52, wherein when the reference for selection is set to the time, the display/preservation selection device can be used to set the predetermined frame image to any frame image.

54. An optical scanning probe system according to Claim 45, wherein when the reference for selection is set to the time, the control device controls the image display device and digital image preservation unit so that display and/or preservation is performed during a predetermined time but not performed during the other time.

55. An optical scanning probe system according to Claim 54, wherein when the reference for selection is set to the time, the display/preservation selection device can be used to set the predetermined time to any time.

56. An optical scanning probe system according to Claim 43, wherein the display/preservation selection device can be used to select or designate the simultaneously preserved data from at least one and more among a normal endoscopic image, a scale, any text, and any cursor.

57. An optical scanning probe system according to Claim 43, wherein the display/preservation selection device can be used to select or designate the timing of

preservation from among:

the timing of starting and/or stopping observation which is determined by the control device;

the timing of displaying a still image or the timing before or after the display;

the timing of starting and/or stopping emission of light from the light source which is determined by the control device; and

the timing of executing and/or canceling blur correction which is determined by the control device.

58. An optical scanning probe system according to Claim 43, wherein the display/preservation selection device can be used to designate execution or cancellation of blur correction.

59. An optical scanning probe system according to Claim 42, wherein together with an image displayed on the image display device, at least one of a normal endoscopic image, a scale indicating the size of an object depicted in an image displayed on the image display device, any text, and any cursor can be displayed on the image display device.

60. An optical scanning probe system according to Claim 42, wherein the display/preservation selection device

includes an input device used to designate the display/preservation parameters.

61. An optical scanning probe system according to Claim 60, wherein the input device is a keyboard whose keys can be pressed with a hand.

62. An optical scanning probe system according to Claim 60, wherein the input device is a mouse capable of being clicked or dragged with a hand or a trackball.

63. An optical scanning probe system according to Claim 1, wherein the image digitization unit is an A/D converter.

64. An optical scanning probe system according to Claim 63, wherein gradation permitted by the A/D converter is expressed with at least 8 bits.

65. An optical scanning probe system according to Claim 1, wherein the digital image preservation unit is formed with a memory in which a digital signal is preserved.

66. An optical scanning probe system according to Claim 65, wherein the memory is a cine memory having a large

storage capacity.

67. An optical probe system comprising:
 - an optical probe that is inserted into a body cavity;
 - a light source that generates light which is irradiated to an object;
 - a condenser that converges or emits light emanating from a light source included in the distal section of the optical probe;
 - an optical scanning unit that scans a focal point on an object, at which the light is converged by the condenser, two-dimensionally in a direction orthogonal to the optical-axis directions of the condenser;
 - a photo detector that detects light returning from the object; and
 - a display device on which a luminance signal sampled by the photo detector is two-dimensionally displayed according to a magnitude of scanning performed by the optical scanning unit, wherein:
 - an image is displayed on the display device with at least part of an entire scanned range masked.

68. An optical scanning probe system according to Claim 67, wherein the optical scanning unit sweeps light to form a raster, and an image is displayed on the display

device with a diagonal part of a scanned range masked.

69. An optical scanning probe system according to Claim 67, wherein an image is displayed on the display device with part of a field of view, which lies above an optical axis by a certain magnitude or more, masked.

70. An optical probe system comprising:
an optical probe that is inserted into a body cavity;
a light source that generates light which is irradiated to an object;
a high-magnification observation unit included in the distal section of the optical probe;
an image parameter sampling unit that samples an image parameter from an image produced by the high-magnification observation unit;
an optimization parameter calculation unit that calculates an optimization parameter on the basis of the image parameter;
an image optimization unit that optimizes an image according to the optimization parameter; and
an image display device on which an optimized image is displayed.

71. An optical scanning probe system according to

Claim 70, further comprising an image preservation unit in which the image is preserved.

72. An optical scanning probe system according to Claim 71, wherein the image preservation unit is an image preservation unit in which a digital image is preserved.

73. An optical probe system comprising:
an optical probe that is inserted into a body cavity;
a light source that generates light which is irradiated to an object;
a high-magnification observation unit included in the distal section of the optical probe;
an image digitization unit that digitizes a luminance signal produced by the high-magnification observation unit;
an image display device on which an image is displayed;
a digital image preservation unit in which a digitized image is preserved;
a display/preservation selection device for use in selecting or designating display/preservation parameters, which determine a method of displaying and preserving an image, on the image display device; and
a control device that controls at least one of the light source, image display device, and digital image preservation unit according to the display/preservation

parameters, and executes display and preservation.

74. An optical scanning probe system according to Claim 73, wherein the display/preservation parameters include at least one of:

a parameter concerning a display/preservation mode in which at least a specific image is displayed and/or preserved;

a parameter concerning a reference for selection based on which an image to be displayed on the image display device, that is, an object of display and/or preservation is specified;

a parameter concerning simultaneously preserved data, that is, data other than an image that should be preserved together with an image displayed on the image display device;

a parameter concerning timing of preservation, that is, at what timing an image displayed on the image display device should be preserved; and

a parameter concerning blur correction, that is, whether a blur in an image displayed on the image display device should be corrected.